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TREATMENT OF RADIONUCLIDE CONTAMINATED SOILS

Rockwell International
Aerospace Operations
Rocky Flats Plant
Golden, CO 80402

June 1988

Authors:
S. A. Pettis
A. J. Kallas
R. L. Kochen
S. C. McGlochlin

(U)

"Reviewed for Classification
by A J Kallas

ADMIN RECORD

SW-SW-A-003354

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ABSTRACT

Rockwell International, Rocky Flats Plant, is committed to remediating, within the scope of RCRA/CERCLA, Solid Waste Management Units (SWMUs) at Rocky Flats found to be contaminated with hazardous substances. SWMUs found to have radionuclide (uranium, plutonium, and/or americium) concentrations in the soils and/or groundwater that exceed background levels or regulatory limits will also be included in this remediation effort.

The intent of this paper is to briefly summarize past and present efforts by Rockwell International, Rocky Flats Plant, to identify treatment technologies appropriate for remediating actinide contaminated soils. Many of the promising soil treatments evaluated in Rocky Flats' laboratories during the late 1970's and early 1980's are currently being revisited These technologies are generally directed toward substantially reducing the volume of contaminated soils, with the subsequent intention of disposing of a small remaining concentrated fraction of contaminated soil in a facility approved to receive radioactive wastes. Treatment processes currently being evaluated include wet screening, scrubbing (vibratory and attrition), mineral jigs, and acid leaching. Wash solutions used in these processes will be treated to remove actinides, and recycled back to the process. Past investigations have included evaluations of dry screening, wet screening, scrubbing, ultrasonics, chemical oxidation, calcination, desliming, flotation, and heavy-liquid density separation

INTRODUCTION

Rocky Flats Plant, a Department of Energy (DOE) defense facility located 16 miles northwest of Denver and operated by Rockwell International, is continuing an on-going evaluation of technologies applicable to the volume reduction of plutonium (^{239}Pu) and americium (^{241}Am) contaminated soils. Beginning in 1958, a 13,600 m^2 area was used to store drums of cutting oils contaminated with plutonium and uranium cuttings and carbon tetrachloride After a period of time, a number of drums appeared corroded and leaking All drums were removed from the area by January 1968.[1-4]

Soil contamination in the area was estimated to range from 2,000 to 300,000 disintegrations per minute (dpm) per 100 cm^2 of soil surface area and was detected to depths of 3 to 20 cm. In 1969 successive layers of gravel (15 cm), fill dirt (8 cm), and asphalt (7.5 cm) were placed over the area The 113 m by 120 m pad area covers roughly 18,000 tons of soil contaminated with approximately 80 to 90 grams of plutonium[1-4] Monitoring at the four corners of the pad area, begun in 1969, indicated that the actinide contaminants were not being transported beneath the pad. Therefore, the actinides were assumed to be effectively contained. However, concerns over possible long-range diffusion of the contaminants into the environment led to laboratory evaluations of various soil remediation methods.[2]

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Beginning in 1972, Rocky Flats' personnel began evaluating many technologies at the laboratory-scale level to determine the most effective method of decontaminating actinide-contaminated soil.[4] Methods evaluated included dry screening, wet screening, scrubbing, ultrasonics, chemical oxidation, calcination, desliming, flotation, and heavy-liquid separation.[1] A brief description of each technique and the experiments conducted will be included in this paper; however, only the most promising of the technologies were pursued in more detail.

Prior to the laboratory evaluations, it was discovered that both particulate (plutonium dioxide, PuO_2, mean diameter=0.2 microns) and dissolved (possibly chloride and/or 2,6-di-tert-butyl-4-methylphenol complexes) forms of plutonium existed.[2,4] The dissolved plutonium is assumed to have been adsorbed to the clay and organic materials and/or precipitated as a $Fe_2O_3 \cdot PuO_2$ coating on the mineral surfaces.[2] It was also determined that plutonium preferentially adsorbed to the smaller soil fractions.[1,4] Due to this and the fact that soil at Rocky Flats is very rocky in nature, physical grinding and size separation techniques, such as scrubbing and wet screening, appear to have the greatest potential for successful soil decontamination at the full-scale level.[1,2,4]

INITIAL LABORATORY EXPERIMENTATION[1,4]

Soil samples used during the laboratory experiments were obtained from the pad area. Six of the samples were collected from beneath the asphalt pad, while two samples were obtained from an area to the southeast, where wind had blown contaminants before the pad was in place. Results of soil analyses are shown in Table 1. Prior to all laboratory experimentation, all soil samples (4 kg) were oven-dried at 100°C for 5 days. Samples were then weighed, mixed, and sampled.

Table 1: Average Plutonium and Americium Levels[1,4]

Sample Number*	Disintegrations/ Minute/Gram (dpm/g) ^{239}Pu	^{241}Am	Sampling Depth from the Top of the Pad (cm)
A	1,200	330	---
B	11,900	1,400	---
P-1	940	620	46
P-2	1,400	1,100	61
P-3	8,000	1,000	56
P-4	45,000	4,200	66
P-5	14,000	4,100	61
P-6	17,000	5,000	61

*Samples A and B were taken from the windblown areas; samples P-1 through P-6 were taken from beneath the pad.

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Primary Treatment Method

Screening

Dry screening was accomplished with a Ro-Tap[R] sieve shaker equipped with 20 cm diameter sieves. Each screening operation lasted 10 minutes. Dry screening did not effectively decontaminate the large >4 mm soil fraction (60 wt%) to the desired level of less than 25 dpm/g.

Wet screening of the soils was accomplished both mechanically with a converted Tyler RX-24 shaker and manually using a sieve shaker. Wash solutions were filtered with fines being collected in a Buchner funnel containing No 42 Whatman[R] filter paper. The samples were then dried, mixed, and sampled. The wet screening process was successful in decontaminating the >4 mm soil fraction (60 wt% of initial soil) to less than 5 dpm/g Pu and Am. The process also significantly reduced the activity in the 4 mm to 2.4 mm soil fraction to an average of 670 dpm/g Pu The combination of these two soil fractions (>2.4 mm, 65 wt%) was decontaminated to less than 12 dpm/g Pu and 6 dpm/g Am. Filtered wash solutions remained relatively free of activity (<5 dpm/g).

Secondary Treatment Methods

Secondary treatment experiments were then conducted on the contaminated soil fractions (35% of initial soil volume) obtained from the wet screening process. Decontamination techniques evaluated included attrition scrubbing, ultrasonic scrubbing, oxidation, calcination, desliming, flotation, and heavy liquid density separation.

Scrubbing

Attrition scrubbing experiments utilized either a lab model Fagergren[R] flotation machine containing 3 six-bladed, stainless steel opposed pitch turbine type propellers on a stainless steel drive shaft or a Waring Blendor[R] model 7010S. The first unit used 100 g and 200 g soil samples in 150 ml and 200 ml of wash solution, respectively, and operated at 900 rpm for 10 minutes. The second unit used 100 g and 300 g soil samples in 150 ml and 200 ml of wash solution, respectively, and operated at 23,000 rpm for 10 minutes. After attrition scrubbing, the samples were wet screened.

Ultrasonic scrubbing was accomplished using a Branson Sonifier[R] model J-17A. Soil samples of 100 g and 200 g were suspended in wash solutions of 150 ml (pH 9.5) and 300 ml (pH 6.7), respectively. The immersion horn (19 mm diameter, 12.7 cm long) of the ultrasonic probe was supported vertically downward into the flask and operated at full power for ten minutes.

The scrubbing experiments also used various surfactant wash solutions to determine their effectiveness as compared to tests using distilled water alone. The most effective wash solutions appeared to be Calgon (10 wt%), Turco 4324 (10 wt%), and oxalic acid (0.1 to 0.2 wt%).

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Attrition scrubbing effectively reduced the level of contaminants to less than 40 dpm/g in the 2.4 to 0.42 mm soil fraction (11 wt% of initial soil) as well as reducing the size of the soil particles. Recycling of the surfactant wash solution appears feasible, with the Calgon solution appearing most promising. Ultrasonic scrubbing results were inconclusive, however, no grain size reduction was observed.

Oxidation and Calcination

Oxidation and calcination experiments were conducted in an attempt to remove organic material from the soil, and thus, provide for the more effective removal of the contaminants from the soil. Oxidation experiments were evaluated using either a 5.25% sodium hypochlorite solution or a 35% hydrogen peroxide solution. A 100 g soil sample, slurried with 100 ml of distilled water (pH 4 5), was treated with successive additions of oxidant totaling 50 ml. Initially 50°C temperatures were induced, with the final solution mixture being maintained at its boiling point for 30 minutes Subsequent experiments were run with twice the volume of soil and reagents The samples were then attrition scrubbed at 900 rpm and mechanically wet screened.

For the calcination experiments, 100 g and 200 g samples were calcined in a Thermolyne[R] furnace for 4 hours at temperatures ranging from 200°C to 800°C. The samples were then cooled and attrition scrubbed at 900 rpm and mechanically wet screened with a wash solution (pH 9.5)

Oxidation and calcination experiments were not successful in obtaining desired plutonium residual levels. However, it was determined that hydrogen peroxide performed better than sodium hypochlorite, and that the procedure worked better when the oxidized soil was adjusted to a pH of 9.5 prior to attrition scrubbing and wet screening. Also, calcination was determined more effective when operation occurred at 200°C as opposed to 500°C and 800°C.

Desliming and Flotation

One experiment using a 300 g, <4 mm soil sample was conducted to determine the effectiveness of desliming. The soil was combined, in three successive steps, with 500 ml, 250 ml, and 250 ml of distilled water (pH 6.7) During each step of the process, the slurry was shaken 10 times and allowed to settle 5 minutes. The top of the solution (slimes) were then drawn into a vacuum flask, while the bottoms (sands) remained. After the three steps the sands were attrition scrubbed and wet screened.

The flotation experiments consisted of bubbling air through a soil slurry contained in a small flask. The air created a foaming action that separated less dense soil particles away from the soil bulk and into a collection beaker. Soil was wet screened before sampling. One flotation run was also conducted with a 10 wt% Turco wash solution.

Both soil desliming and flotation experiments indicated no significant improvement over the attrition scrubbing process. However, the use of various surfactant wash reagents may result in improved results.

Heavy Liquid Density Separation

Heavy liquid density experiments were conducted using 100 g and 200 g soil samples combined with 150-200 ml thallium mallonate formate (pH 9.0, density 4.0 g/l). The slurry was attrition scrubbed at 900 rpm for ten minutes and combined in a separatory funnel with 150-200 ml distilled water (pH 9.0). After 5 days, the slurry was separated and mechanically wet screened.

Inconclusive separation results were obtained using the heavy liquid density separation with thallium mallonate formate .

Tertiary Treatment Methods

Tertiary treatment methods thought applicable for the further volume reduction of concentrated contaminated soil (20-25% of initial soil volume) included acid leaching and vitrification. Acid leaching appeared to be economically impractical at the full-scale. An attempt to vitrify with heat alone reduced the soil volume and decreased PuO_2 mobility, but also resulted in an increase in the soil dispersibility. An estimated volume reduction of up to 26% was obtained by heating various 13 g to 18 g samples of an oven dried soil to temperatures of 600°C, 800°C, and 1,000°C Subsequent tests were conducted at 1,200°C and 1,400°C. Soil vitrification was also conducted using glass forming and modifying agents. Soil mixtures were heated to temperatures ranging from 1,250°C to 1,450°C, poured into graphite molds, annealed at 500°C for three hours, and slowly cooled to ambient temperatures. This process resulted in soil volume increases ranging from 0% to 7%.

CONTINUED LABORATORY EXPERIMENTATION

Additional laboratory experiments were conducted to determine the most effective surfactant wash solutions for the actinide decontamination of Rocky Flats soils. Based on these results and the previously described laboratory evaluations, five decontamination processes were evaluated further:[2,5,6]

1. Wet screening at high pH.
2. Attrition scrubbing with Calgon at elevated pH.
3. Attrition scrubbing at low pH.
4. Cationic flotation of clays.
5. Vibratory grinding.

Surfactants

Laboratory experiments were conducted evaluating forty surfactant additives, including acids (HCl, HNO_3, HF, H_2SO_4, and H_3PO_4) and detergents (Calgon^R, Oakite^R, Turco 4324^R, Pierce^R, and Basic H^R).[4,5] Three of these

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wash solutions were then compared to obtain a relative measure of performance on coarse Rocky Flats soils, as well as soil from other DOE facilities.[5] For Rocky Flats soils, a high pH solution (pH 12.5) effectively concentrated activity in the fine soil fraction and dissolved little of the activity. Both the strong acid solution (2N HCl) and a less corrosive weak acid/surfactant solution (2% HNO3, 0.2% HF, 2% Pine Oil, and 5% Calgon) had similar results in leaching activity from the fine soil fraction.

Wet Screening at High pH[2]

The wet screening process, with pH adjusted to 11, was shown to be effective for decontaminating the >0.42 mm soil fraction to less than 30 dpm/g The amount of soil that would be decontaminated in this processing step, using Rocky Flats soils, is approximately 60 to 70 wt% of the initial soil volume. Use of sodium hydroxide (NaOH) is recommended as Na^+ and OH^- ions both act to disperse the clay particles and create colloidal suspensions, resulting in a more effective soil separation

Attrition Scrubbing with Calgon at Elevated pH[2]

Attrition scrubbing at a high pH using a Calgon solution can be utilized to reduce the soil volume (<2.4 mm) by 80 wt%. A soil/Calgon slurry was scrubbed in a rotary-type attrition scrubber for 5 to 7 minutes. The process was completed four times with the fines being decanted after each scrub Most of the contamination was found to be removed after the first run Approximately 80 wt% of the soil introduced to the scrubber was decontaminated to an activity of less than 30 dpm/g. Two processes are involved in the attrition scrubbing operation. The high pH solution acts to disperse the clay particles, while the physical grinding action acts to scrape away the contaminated outer surfaces of the soil particles.

Attrition Scrubbing at Low pH[2]

Attrition scrubbing was also investigated using a 2% HNO_3, 0 2% HF, 2% pine oil, and 5% Calgon wash solution. The slurry was scrubbed a total of five times in a rotary-type scrubber with a total of 84 wt% of the soil being decontaminated to less than 5 dpm/g. The soil is decontaminated as the acid solution attacks the outer surface of the soil particles No colloidal suspensions are formed in the process; however, the acid solution does dissolve some of the plutonium. In order to recycle the wash solution, dissolved plutonium must be removed either by co-precipitation of plutonium with $BaSO_4$ or $Fe(OH)_3$ or by adsorption on the hydroxide form of an anion exchange resin. The latter process actually involves the precipitation of $Pu(OH)_4$ on the resin material.

Cationic Flotation[2]

This process utilizes a cationic flotation agent such as an amine to float the anionic clay particles. A quartz suppressor can then be added to the mixture to allow the separation of abraded rock particles and the clay particles when the solution is scrubbed at a high speed (>1,000 rpm).

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Further development of the cationic flotation process is required for the process to be considered applicable for soil decontamination at the full-scale level

Vibratory Grinding[6]

Vibratory grinding was also evaluated to determine its effectiveness for decontaminating transuranic-contaminated soils as compared to attrition scrubbing with a rotating mill apparatus The experiments utilized a Roto-Finish Spiratron ST-1 vibratory grinder and used actual soil from the contaminated pad area. Improved scrubbing action, due to the rubbing action of soil particles as opposed to soil breakage caused by particle impact, was observed. Both weak acid/surfactant and strong acid solutions appeared to enhance the decontamination of the less than 5 mesh soil particles. A high pH wash solution appeared to aid in the decontamination process by making the removal of the fine material easier and quicker; however, the solution did .not improve the degree to which the soil was decontaminated.

PILOT-SCALE EXPERIMENTATION

Pilot-scale equipment evaluations were conducted to provide data for the design of a full-scale, mobile soil decontamination treatment process capable of processing 10 tons of soil per hour.[2,7] Based on the laboratory evaluations, the attrition scrubbing process at high pH was determined to be the most feasible to scale up to full-scale operation[2] (see Figures 1 and 2). The pilot-scale process began with a 4-inch grizzly screen to remove the large rocks. A rotary Trommel[R] scrubber/screen was then used to separate material greater than 0.25 inches. The fines were then washed and screened to remove the greater than 0.42 mm soil fraction. The fines were then transported to a three stage, one-inch liquid cyclone. The smallest fraction (<10 microns) would contain the concentrated contaminants and would be packaged and shipped off-site. A total weight reduction of the initial contaminated soil of 88% was expected. Evaluation of wash solution recycle was also included in the process.

Pilot-scale equipment evaluation was conducted on "cold" soil at the rate of 275 kg/hr and "hot" soil at the rate of 70 kg/hr.[2,7] Table 2 shows the mass balance of the pilot-scale testing conducted by the Colorado School of Mines Research Institute on the "cold" soils. This table shows how contaminated soils would be progressively concentrated in smaller soil fractions, assuming the contaminants will remain with the smallest soil fractions. Results of the evaluations were promising; however, underflow from the third stage of the cyclone would produce unacceptable levels of contaminants.

Pilot-scale equipment evaluations, using "hot" soil samples obtained from beneath the pad, were conducted at Rocky Flats.[7] Initially it was not anticipated that pilot-scale evaluations would be conducted using "hot" soils. However, concerns arose over the lack of large-scale equipment tests with "hot" soils. Therefore, "hot" soil testing was conducted with a bench-scale equipment test loop. Due to the time constraints in obtaining

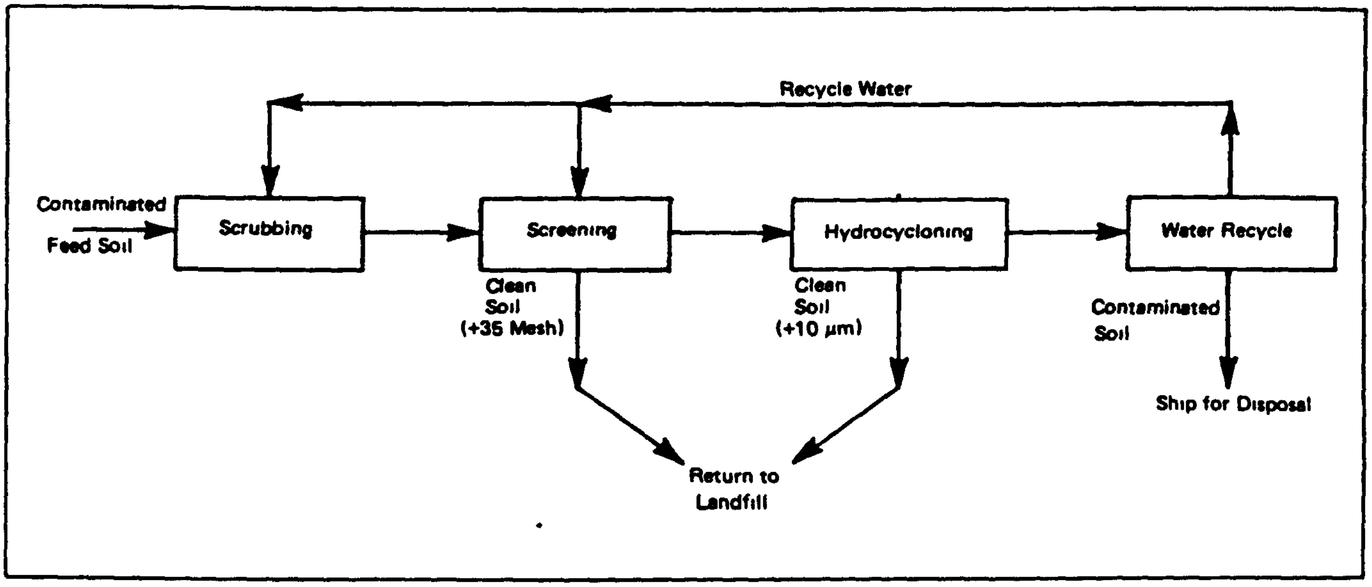

FIGURE 1. Conceptual Soil Decontamination Process Flow Sheet

FIGURE 2. Pilot Scale Equipment Test for Soil Decontamination

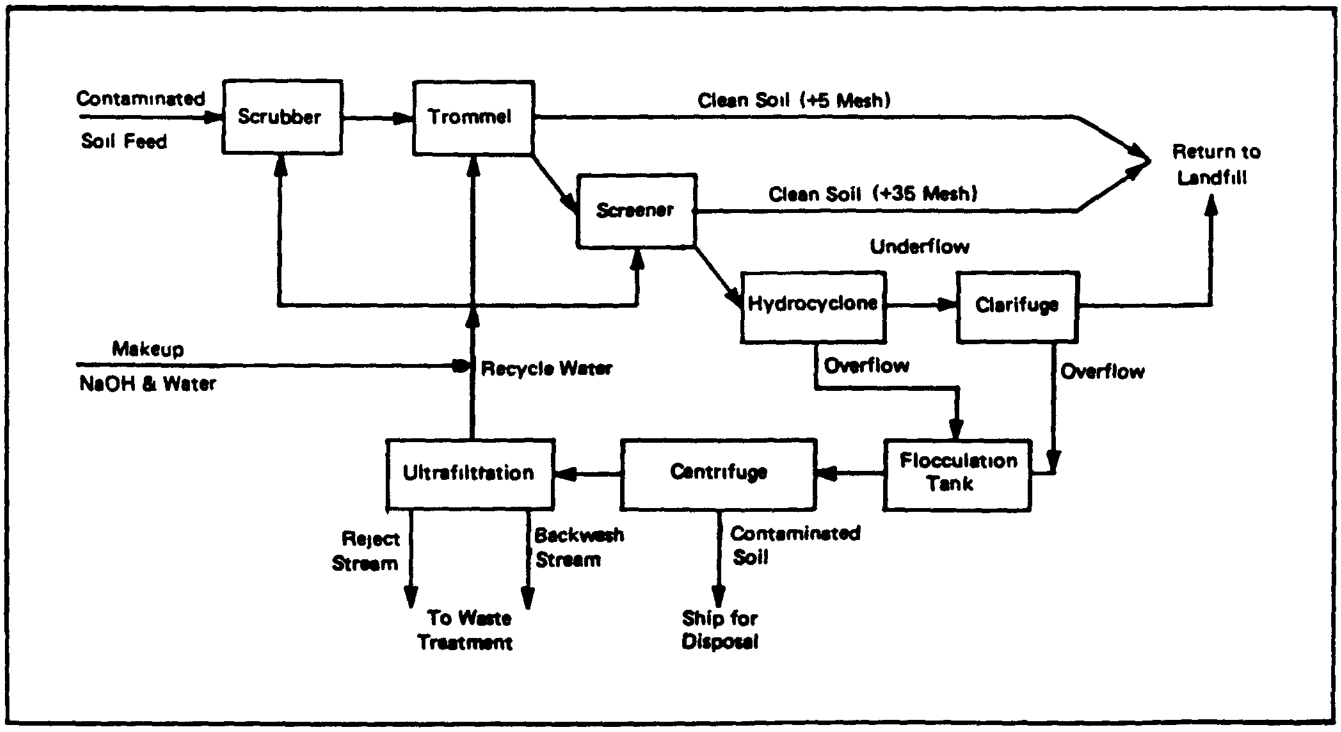

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Table 2: Pilot Plant Soil Decontamination Results.[2]

	Solids Density		Particle Size Distribution	
Process/Soil Description	Weight % of Initial Soil *(wt%)	Solids (wt%)	<37 m (wt%)	<10 m (wt%)
1) Grizzly				
Feed	100.0	100.0	100.0	100.0
>100 mm	15 0	100 0	0 0	0.0
100 mm to 38 mm	25 0	100 0	0.0	0.0

* 40.0% removed by grizzly, 60.0% sent to scrubber.

2) Scrubber				
Feed <38 mm	60.0	100.0	100 0	100.0
Total Discharge	60.0	63.0	100.0	100.0
38 mm to 6 mm	26.5	70 0	0 6	0.4

* 26.5% removed by screen on end of scrubber, 33.5% sent to vibrating screens.

3) Sweco Vibrating Screen				
Oversize 6 mm to 0.42 mm	10.9	77.3	0.06	0.04
Undersize <0.42 mm	22 6	8.5**	99.3	99.6

* 10.9% removed, 22.6% sent to cyclones.

**This product was thickened to 25% solids prior to 1st stage cycloning.

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Table 2 (cont.): **Pilot Plant Soil Decontamination Results.**

Process/Soil Description	Weight % of Initial Soil *(wt%)	Solids Density: Solids (wt%)	Particle Size Distribution: <37 m (wt%)	Particle Size Distribution: <10 m (wt%)
4) 1st Stage Cyclone				
Overflow	15.1	18.0	91.1	92 6
Underflow	7.5	68 0	8 2	7.0

* 15.1% sent to 3rd stage, 7 5% sent to 2nd stage.

Process/Soil Description	Weight % of Initial Soil *(wt%)	Solids Density: Solids (wt%)	Particle Size Distribution: <37 m (wt%)	Particle Size Distribution: <10 m (wt%)
5) 2nd Stage Cyclone				
Overflow	1.1	5.0	6 6	6.6
Underflow	6 4	71.0	1.6	0.4

* 6.4% Removed, 1.1% to be treated further.

Process/Soil Description	Weight % of Initial Soil *(wt%)	Solids Density: Solids (wt%)	Particle Size Distribution: <37 m (wt%)	Particle Size Distribution: <10 m (wt%)
6) 3rd Stage Cyclone				
Overflow	10 0	9.5	0 0	75.6
Underflow	5.1	33.1	0.0	17 0

equipment, the operation resembled batch processing and never did reach a dynamic equilibrium condition

Equipment[7]

A bench-scale equipment test loop was evaluated using "hot" soils. A vibratory feeder with an attached hopper was used to feed soil (5 kg packages) at the rate of 34 to 114 kg/hr to a drum roller The 115 L drum roller (0.46 m diameter) was fed NaOH (pH 11) at the rate of 3.8 L/min. The resulting slurry was agitated with lifters contained in the drum roller. The drum roller was sealed at both ends except for a 0.15 m feed hole and a 0.25 m discharge hole which fed the trommel screen

The trommel screen, equipped with a spray head to dispense NaOH (pH 11) at the rate of 3.8 L/min, provided for the separation of the greater than 4 mm soil fraction from the slurry. This material, now decontaminated, was collected in plastic-lined drums prior to sampling. The <4 mm soil slurry was funneled into a SWECO^R vibratory wet screen. The vibratory wet screen was provided with two NaOH spray heads, each operating at the rate of 1.9 L/min Decontaminated >0.42 mm soil was collected in plastic-lined drums, while the soil slurry was pumped to a 115 L hydrocyclone feed tank.

A Sandpiper^R pneumatic diaphragm pump equipped with a pneumatic pulse dampener supplied the high pressure feed required for good separation in the 0.25 m hydrocyclone. The hydrocyclone operated at the rate of 23 L/min. Underflow from the hydrocyclone (>10 microns) was discharged at atmospheric pressure into an open drum and immediately pumped to a continuous solid-bowl clarifuge.

The clarifuge, operated at 3,600 rpm, removed essentially all the noncolloidal solids. Brief process shutdowns were incurred to manually empty the clarifuge bowl. Colloidal solids from the clarifuge were then recombined with the solids (overflow) from the hydrocyclone in a lined 40 L drum which served as a flocculation tank.

The flocculation tank was equipped with an air sparge line to mix the soil slurry and the flocculents. The flocculated slurry was then pumped to a continuous solid-bowl centrifuge, operated at 900 rpm. The solids formed a high-water content, gelatinous solid, while the overflow was collected in a lined 20 L drum. The overflow was then pumped to a 115 L ultrafiltration feed tank.

The ultrafiltration unit removed all remaining suspended solids Two waste streams were produced: a reject flow (10% of the total flow, and a backwash flow (40 to 80 L). The unit was equipped with a backwash tank and two 115 L tanks for the collection of reject and product flows. Clean product water was supplied back to the drum roller and the various spray heads.

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Results[7]

All tests indicated that the drum roller easily separated the fines and gravel. "Cold" tests indicated that both drum and attrition scrubbing were equally effective.

The SWECO trommel screen was very effective for soil separation of both the >4 mm and >0.42 mm soil fractions. Use of a double trommel utilizing a 4 mm screen with a 0.42 mm screen situated concentrically around it separated the gravel into two fractions and performed about as well as the SWECO. However, a 0.175 mm screen became 40% plugged in less than five minutes.

The capacities of the hydrocyclones purchased were inappropriate for the rest of the equipment being tested. Therefore the hydrocyclones were only cold tested. The <4 mm soil fraction was directed to the clarifuge

Flocculation tests indicated that both alum and an organic polymer, Purefloc®, were necessary for a clear supernatant.

A continuous, low speed centrifuge (solid bowl) would be suitable for the removal of flocculated solids. Centrifuging resulted in a cake of 30% solids, with the <2 micron fines still in the liquid.

The ultrafiltration unit produced high quality water but plugged too quickly and required frequent backwashes. The ratio of product water to reject flow was as high as 10:1. However, the unit required a backwash of 80 L, after processing only 200 L of solution.

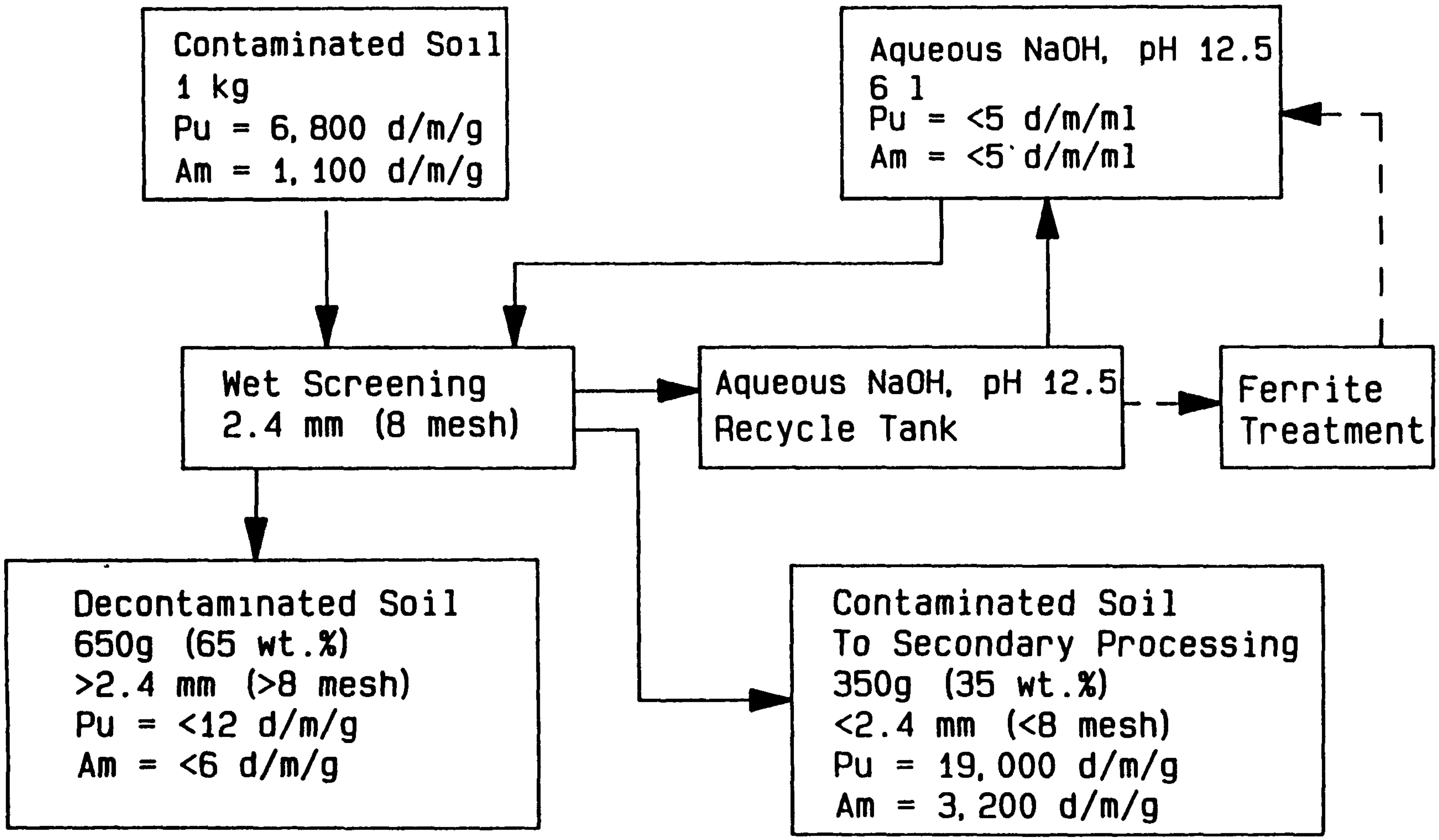
FUTURE WORK

All indications are that the proposed treatment process for the decontamination of actinide contaminated soils at Rocky Flats Plant can be successful at the full-scale level. However, previous experimentation was conducted with a soil decontamination goal of <30 dpm/g.[2,8] The current regulatory limits which Rocky Flats will be required to meet are not known, but may be as low as 1 dpm/g. Also, the "hot" pilot-scale equipment evaluations never did reach a dynamic equilibrium condition, and certain soil fractions (-5+35 mesh) were not consistently decontaminated below 100 dpm/g[2] Additional pilot-plant development was not previously implemented due to funding shortfalls. Thus further pilot-scale soil processing would provide additional data for a full-scale treatment process, as scale-up from laboratory data constitutes an unacceptable economic and environmental risk.

Based on the previous successful equipment evaluations, proposed pilot-plant operations would include wet screening, attrition scrubbing, and mineral jig separation techniques (see Figures 3 and 4). Actual pilot-scale operations, however, may vary from the following proposed flow scheme, dependent on the results of additional bench-scale work currently being conducted.

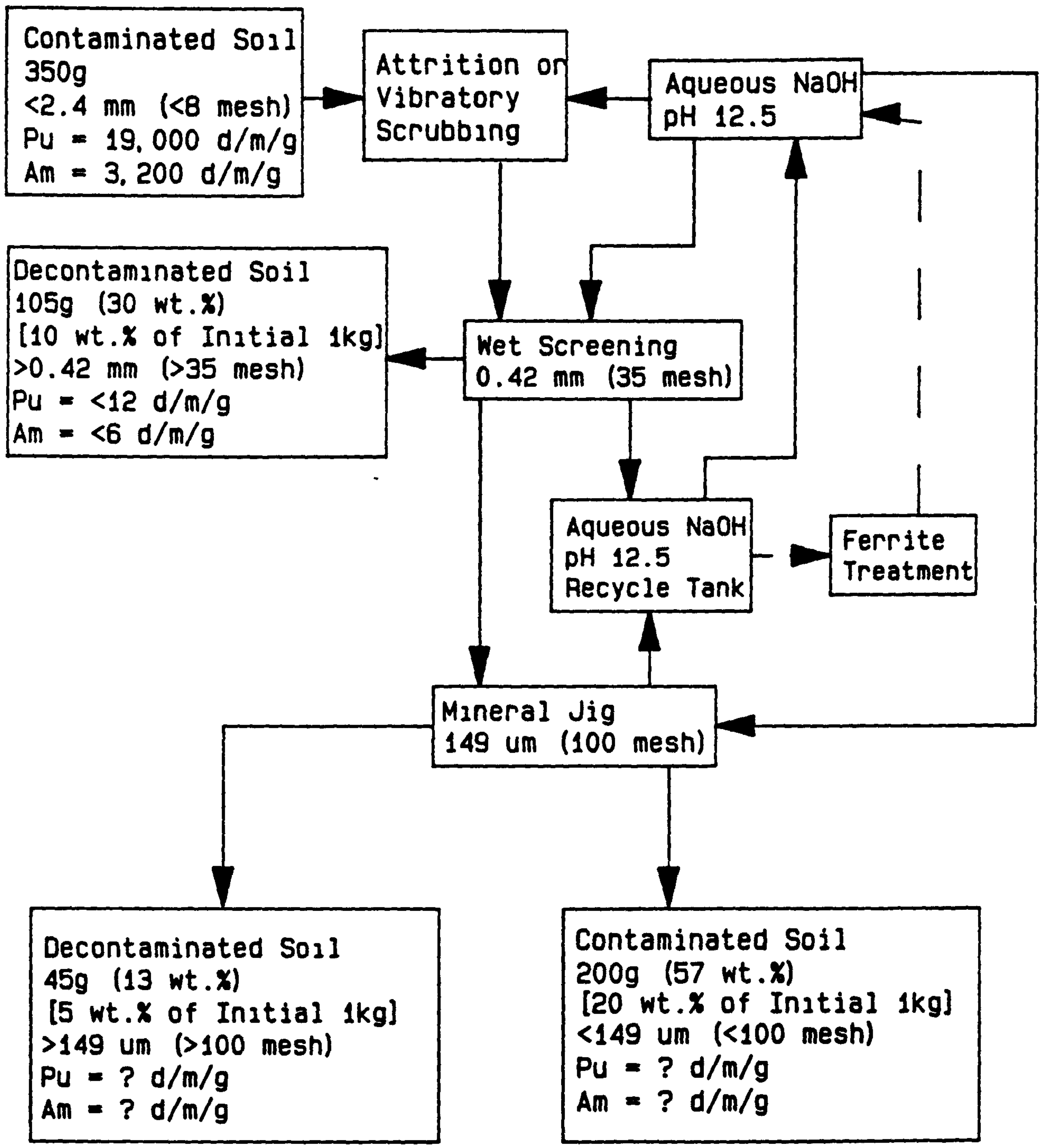
FIGURE

Conceptual Primary Process



FIGURE

Conceptual Secondary Process



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Contaminated soil would be transported to the pilot plant and fed onto a vibratory feeder. The feeder would transfer the soil to a screen log washer (drum roller) at the rate of 75-250 lb/hr. Sodium hydroxide (NaOH) would be added to obtain a slurry with pH 12.5. The slurry would then be discharged to a trommel screen which will remove decontaminated, >8 mesh soil. The <8 mesh soil would then be funneled into an attrition scrubber After adequate mixing, the slurry would be transferred from the attrition scrubber to a vibratory screen which would remove decontaminated, >35 mesh soil. Next the slurry would be fed to a mineral jig. Both decontaminated soils (>100 mesh) and contaminated soils (<100 mesh) would exit the mineral jig and be collected in plastic-lined drums and sampled for laboratory analyses.

Sodium hydroxide solution would be used in the screen log washer (drum roller), attrition scrubber, and mineral jig to maintain a slurry pH of 12.5. NaOH would also be used as a spray rinse of the decontaminated soils at both the trommel and vibratory screens. NaOH solution would be collected from the various units and passed through a column of activated ferrite. The activated ferrite column would ensure that the NaOH solution remains free of actinides The treated NaOH solution would then be recycled back through the soil treatment process.

CONCLUSIONS

Rockwell International, Rocky Flats Plant, is committed to remediating, within the scope of RCRA/CERCLA, Solid Waste Management Units (SWMUs) at Rocky Flats found to be contaminated with hazardous substances SWMUs found to have radionuclide (uranium, plutonium, and/or americium) concentrations in the soils and/or groundwater that exceed background levels or regulatory limits will also be included in this remediation effort. A full-scale treatment process may be required to meet RCRA/CERCLA requirements for the actinide decontamination of Rocky Flats' soils.

Past and present efforts by Rockwell International, Rocky Flats Plant, to identify treatment technologies appropriate for remediating actinide contaminated soils have been presented. Many of the promising soil treatments evaluated in Rocky Flats' laboratories during the late 1970's and early 1980's are currently being revisited. These technologies are generally directed toward substantially reducing the volume of contaminated soils, with the subsequent intention of disposing of a small remaining concentrated fraction of contaminated soil in a facility approved to receive radioactive wastes. Treatment processes currently being evaluated include wet screening, scrubbing (vibratory and attrition), mineral jigs, and acid leaching Wash solutions used in these processes will be treated to remove actinides, and recyclec process Past investigations have included evaluatic et screening, scrubbing, ultrasonics, chemical desliming, flotation, and heavy-liquid separation

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All indications are that the prop utilizing a combination of wet screening, attr mineral jig

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technologies for the decontamination of actinide contaminated soils at Rocky Flats Plant can be successful at the full-scale level. However, initial pilot-scale equipment evaluations never did reach a dynamic equilibrium condition, and certain soil fractions (-5+35 mesh) were not consistently decontaminated to appropriate levels (<30 dpm/g). Additional pilot-plant development was not previously implemented due to funding shortfalls. Thus pilot-scale soil processing is currently being proposed to provide additional data for a full-scale treatment process, as scale-up from laboratory data constitutes an unacceptable economic and environmental risk

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